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4 authors, including:

Mahmoud Jabalameli
Iran University of Medical Sciences

Ali Yeganeh
Iran University of Medical Sciences

Marzieh Nojomi
Iran University of Medical Sciences

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ORIGINAL ARTICLE

Parameters of Lower Extremities Alignment View in Iranian Adult Population

Mahmoud Jabalameli[1], Javad Moghimi[2], Ali Yeganeh[2], and Marzieh Nojomi[3]

[1] *Department of Orthopedic Surgery, Shafa Yahyaiyan Hospital, Iran University of Medical Sciences, Tehran, Iran*
[2] *Department of Orthopedic Surgery, Rasoul Akram Hospital, Iran University of Medical Sciences, Tehran, Iran*
[3] *Department of Community Medicine, School of Medicine, Iran University of Medical Sciences, Tehran, Iran*

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Abstract- Normal axial alignment restoration in lower extremities is crucial for surgeons performing reconstructive surgeries. Since reference normal values of axial alignment are affected by age, sex and ethical issues, we tried to scrutinize these parameters in Iranian adults and compare them with normal values in literatures. Through a cross-sectional design, standing axial alignment views of lower extremities were surveyed from 100 volunteers (50 males & 50 females) aged between 15- 32 years. The lower extremities alignment variables were evaluated during two separate measurements. Total average values were used for comparison among genders. Tibio-femoral mechanical angle depicted mean varus of 1.5 degrees in Iranian population that was significantly higher in male participants. Mean angle between anatomical and mechanical axes of femur was 5.7 ± 1.2º. Knee joint was shown to be medially inclined 3.6 ± 1.7º in men comparing 2 ± 2º of women with significant difference. Joint line congruency angle was medially inclined in all of study participants with mean of 1 ± 1.6º. To compare with anthropometric studies of western populations, Iranian participants had more varus lower limb alignment. It seemed mainly because of larger medially inclined knee joint (knee-joint obliquity). This finding along with more compensatory ankle valgus is similar to results of other Asian studies. Such racial variation should be considered in designing appropriate systems in reconstructive surgery.

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Keywords: Adult, Iran

Introduction

??Delicate correlation exists between human anatomy and function. Adequate knowledge is necessary regarding normal biomechanics of limbs and their variations. Achieving normal axial alignment of lower limb cannot be overemphasized in reconstructive surgery of the knee, such as total knee arthroplasty and high tibial osteotomy (1). Primary reference values were documented by Moreland and Hsu based on radiographic evaluation (2, 3). Subsequently, studies were undertaken to modify the results based on age and sex.

Ethnic differences gained more attention especially with advent of newer designs of TKA prostheses (4-6). A few studies surveyed anatomic differences among Asian populations (7-9). We aimed to establish the lower-limb alignment norms in Iranian population and compare them with those reported from the western and some Asian countries.

Materials and methods

During autumn 2008, a total of 200 patients of hand clinic of Shafa Yahyaian hospital (a referral orthopedic center in capital of Iran) were volunteered to enter the survey. One hundred of them were selected randomly (half of each sex) aged 15- 32 years. Previous history of pain, any deformity or surgery of the lower extremity or trauma were the exclusion criteria of the participants.

A full weight-bearing anteroposterior alignment view of the entire lower limbs was performed with bare foot, patellae facing forward and full extension of knees. X-ray beam was centered on the knee at a distance of 2.5 meters.

The alignment parameters were measured according

Corresponding Author: A. Yeganeh
Department of Orthopedic Surgery, Rasoul Akram Hospital, Iran University of Medical Sciences, Tehran, Iran
Tel: +98 9122187996, Fax: +98 --, E-mail address: yeganeh471@yahoo.com

to the methods described by Moreland with modifications applied by Tang in Chinese population study (2, 8). First, following land marks were determined:

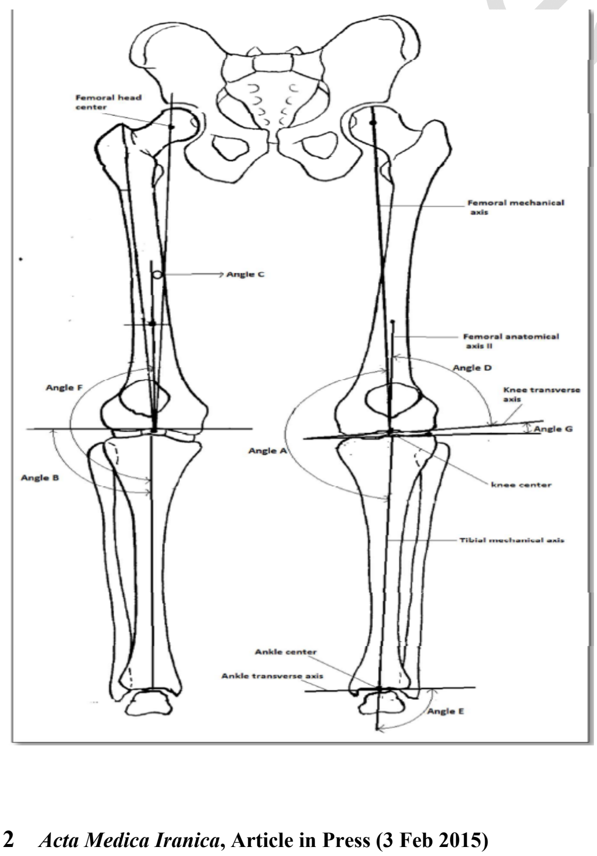
1) The center of the femoral head via Mose circles,

2) Knee center as midpoint between the tips of the tibial spines or center of the tibia/ femoral condyles at the level of the subchondral bone of the medial tibial plateau/ lateral femoral condyle, and

3) Ankle center as a point midway between two malleoli or talus center at the level of the subchondral bone. Moreover, the transverse axis of the knee was drawn as a line tangential to the most distal points of the femoral condyles, and transverse axis of the ankle delineating subchondral plate of the distal part of the tibia.

The femur and tibia mechanical axes were sketched with lines joining the center of the knee to the center of the femoral head and the center of the knee to the center of the ankle, respectively. Anatomical axes of femur were marked in two methods: one connecting femoral shaft center I (at the midshaft level) and another connecting femoral shaft center II (10 cm proximal to knee) to the knee center. We used the latter construct in this study as it represents femoral medullary canal more closely.

Five angles were defined from intersection of above mentioned landmarks (Figure 1).



A: The medial angle formed by the mechanical axes of the femur and the tibia.

B: Inferolateral angle formed by the transverse axis of the knee and the mechanical axis of the tibia that represents knee joint inclination.

C: Angle between mechanical and anatomical II axes of femur.

D: Lateral angle formed by the mechanical axis of the femur and knee transverse axis.

E: Inferolateral angle formed by the transverse axis of the ankle and the anatomical axis of the tibia.

F: Lateral angle between anatomical axes of femur and tibia.

G: Yielded from intersection of lines corresponding distal femur and proximal tibia that is referred to as joint line congruency angle.

H: Resulted from two lines perpendicular to tibia plateau and transverse axis of the ankle. This was further selected to evaluate tibia vara because in most measurements of Iranian cases anatomical and mechanical tibia axes did not match each other.

Finally, femur length was measured as distance between uppermost part of femur head to the center of knee transverse line and tibia length as distance between tibial spines to the center of ankle transverse line.

A calibrated goniometer was used to measure the angles during the two measurements. A finally rechecked average by senior author was assigned as recorded value (mean ± standard deviation). T test was applied for comparison of mean values among genders. Analyses were also made to find any correlation among variables.

Results

From a total of 100 volunteers entered the study, mean ages were 24.4±3.8 years for men and 25.5±4.1 years for women. Averages of height were also calculated 176.1 ± 6.8 and 163.1 ± 5.8 centimeters, for males and females, respectively. Mean weight was 70.8 ± 11 kilograms for men and 63.7 ± 11 for women. Neither of mentioned demographic characteristics was statistically different in comparison among genders. The results related to alignment view values are summarized in table 1.

Angle A depicts overall alignment of the lower extremity. Thus, angle of less than 180 degrees denotes varus alignment. We observed significantly higher varus in men (2.5 ± 3º) than in women (0.7 ± 3º) in Iranian population.

Angle B is considered as an index of the obliquity of the knee joint. The surface would be medially inclined if the angle is larger than 90 degrees. In current male volunteers, this varus of proximal tibia was calculated 3.6 ± 1.7 degrees that revealed remarkable difference comparing with female ones (2 ± 2º).

Angle F is summation of angles B and D. It renders apparent alignment of lower extremities based on anatomical axes. We measured a mean valgus of 4.12º and 2.77º in present female and male subjects, respectively.

Angle G designates knee joint line congruency angle. This was medially inclined in all of participants.

Tibila length showed significant difference between genders. Analysis revealed correlation between tibial length with knee medial inclination(r=0.25) and femur mechanical-anatomical angle (r=-0.35), and also between angle age and lateral distal femoral (D) angle (r=0.25).

Table 1. Comparison of lower limb alignment values reported from this survey and some reference studies

	Present study			**Moreland[2] (Caucasian)**	**Tang et al[8] (Chinese)**	**Hsu et al[3] (white pop.)**	**Khattak[9] (Pakistani)**
	Total	**Male**	**Female**				
A	178.5±2.9	177±3.1	179.3±2.7	178.5± 2.0	177.8 ± 2.7	177.7± 2.3	178.4±2.8
B	92.8±2	93.6±1.7	92±2	93.0 ± 1.6	94.9 ± 2.3	91.0± 1.4	93.4±2.2
C	5.7±1.2	5.7±1	5.7±1.4	5.8 ± 0.7	5.6 ± 0.8	--	5.4º±1.32
D	83.2±3	83.5±3.3	82.8±2.7	--	--	--	
E	91.7±2.8	91.8±2.6	91.6±3	90.7 ± 3.2	91.4 ± 3.1	--	91.7±1.9
F	176.1±3.4*	177.2±3.7	174.8±2.8	--	--	--	--
G	1±1.6	1±1.4	0.97±1.7	--	--	1±1.4(male)/ 0.1±1.9(fem.)	--
H	0.93±3.8	1.1±3.4	0.72±3.4	--	--	--	--
Femoral length	47.1±6.8	49.3±3.9	44.8±8.4	--	--	--	--
Tibial length	39.8±3.7*	41.4±1.1	38.3±1.9	--	--	--	--

*** denotes significant difference among genders in present study**

Discussion

Orthopaedic knee operations such as high tibia osteotomy or TKA often aim at correction of a deformity toward normal alignment. However, such normal anatomy remained an area of controversy because of the substantial ethnical variations (2, 3). Current recommendations applied by designers of most total knee arthroplasty systems are based on alignment values documented by Moreland et al on Caucasians and Hsu et al. on white subjects. Several studies were also conducted during last decade to evaluate these normative in Chinese, Korean and Pakistani population.

In present study over Iranian population, mechanical axes of the femur and the tibia (angle A) did not yield a straight line in either gender. Overall knee varus of 1.5 degrees was measured. This was along with findings of Tang *et al*., (8) and in contrast to the general consensus described that mechanical axes of femur and tibia are aligned (4,10). To justify this difference two points should be noticed. One is more medial inclination (angle B) of the knee beside increased joint line congruency angle (angle G) and the other is apparently higher amount of tibia vara in Iranian population that is less scrutinized in similar studies. Varus alignment was significantly higher among men although Tang reported slightly higher varus in female volunteers.

Angle B is complementary to commonly used medial proximal tibial angle (MPTA) and can be implied as indicator of medial joint inclination. Present male participants like Pakistani population had significantly higher medial inclination. This was contrary to what observed in white and Chinese studies (3,8). Amount of this inclination should be taken into consideration while determining amount of femoral cut external rotation in TKA if tibial cut is placed perpendicular to the mechanical axis (4). It seems that average of 3.65 degrees of external rotation of the femoral component may produce a rectangular flexion gap in Iranian patients.

The angle formed by the mechanical axis of the femur and the femoral anatomical II (angle C) has implication in performing proper distal femoral cut during total knee arthroplasty. In current systems with intramedullary guide for the femoral cut, most of the instrumentations offer a standard six degree cutting block to match the commonly reported physiological valgus angulation of the femur (3,4,11). This guide route is believed to be best represented by femoral anatomical axis II, as applied in previous studies (3,8). Current value of 5.7±1.2 degrees was similar to other surveys measurement. Respecting correct placement of femoral guide entry hole, medial shift from the apex of the intercondylar notch should be taken into consideration. Femoral bow is also posed as an important determinant. However, amount of the medialization and/or choice of short intramedullary rod (as proposed by some authors in highly bowed femur) should be individualized according to the preoperative planning. Of note, designers of some systems assumed smaller cutting block angle in taller individuals supposing that taller patients enjoy a smaller physiological valgus angle of the femur (12). We did not find such correlation during analysis of present data.

Lateral distal femoral angle (LFDA) is derived from angles C and D. It is sometimes assumed to be equal to medial proximal tibial angle (MPTA) (1). We calculated mean LDFA as 88 degrees and based on the results they were not equal, thus it is proposed to measure them discretely.

Ankle is reported to have a valgus of 0-1 degree in different studies (2,8,9). Although it was not statistically significant, we observed more valgus in current population and this may in part be due to compensation of higher knee varus.

Epidemiology studies imply geographical variation in prevalence of osteoarthritis. The ratio of knee:hip osteoarthritis is reported 9:1 for Chinese as an example of Asian population (13), comparing with 3:1 for white individuals of United States, and 1:2 for Swedish (14). The racial differences in the axial alignment of the lower extremity may justify the discrepancy (15). Along with Chinese and Pakistani population, we found larger knee-joint-obliquity angle in present study. Current designs of total knee arthroplasty should take these differences into consideration to provide optimal outcomes.

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